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INJURY BIOMECHANICS RESEARCH *Proceedings of the Tenth International Workshop*

Towards a Physiological Model of the Human Head and Neck

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Introduction

Recently, several models of the human head and neck have been introduced into the biomechanics literature (1-5). They range from lumped-parameter, to sophisticated finite-element models. They all have one thing in common: either the neuromusculature has been entirely ignored, or where it has been taken into account, it was not accounted for with respect to anatomical and inertial reference frames.

The objective of our present project is to obtain the insertions and origins of all the major muscles of the human head and neck, with respect to both inertial and anatomical reference frames.

Materials and Method

Three fresh, middle-aged, unembalmed male cadavera are used for this study. Ideally, each will represent the 5th, 50th, and 95th percentile male. The cadaver is sectioned at the T12-L1 intervertebral disc. A midline incision is made through the anterior and posterior aspects of the skin. The skin is dissected free from its facial attachments exposing the skull and muscles. The mandible is also removed to achieve easy access to muscles from the anterior. The skull is attached to a modified ADA halo-hoop frame. This frame is affixed to a specially designed Plexiglass® fixture with the torso resting prone on the thoracic cage, and the head and neck in a military

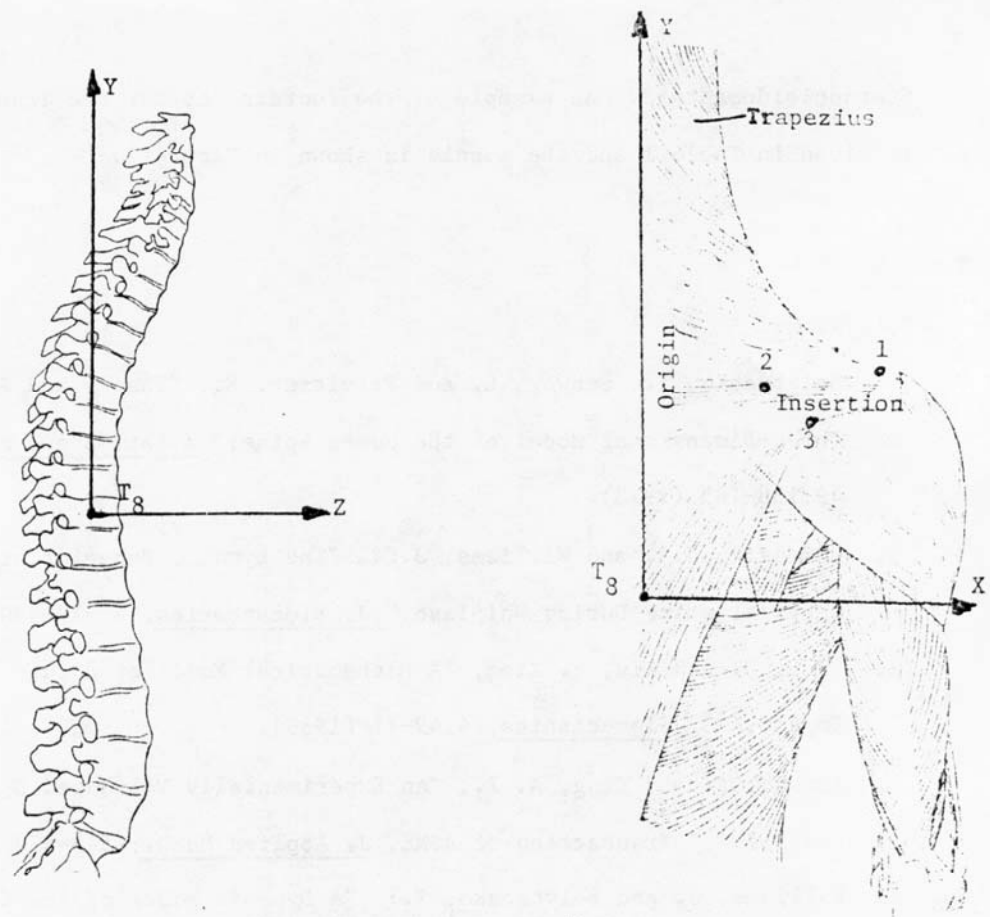
posture. The torso, like the skull, is also clamped rigidly to the base of the fixture. B-B shots are implanted in the occipital protuberance and the spinous processes of C7 and T7-T8. A particular muscle, like the trapezius, is then dissected free from its origins and insertions. Immediately thereafter hypodermic needles of various lengths, and with 1, 2, or 3 B-B shots embedded in its Luer-lock cavity, are implanted into the muscle's origins and insertions. For example, the trapezius muscle was identified by five origin points and three insertion points. The muscle itself is weighed in air, and then placed into a graduated cylinder to determine the volume of physiological saline it displaced. The recorded weight and volume will yield the specific weight for the muscle. Its natural length and maximum width are also recorded. With the head, neck and torso fixed in the halo-hoop fixture, P-A and lateral X-rays are taken. The above procedure is repeated for four muscles, at the most, per each X-ray set. The X-rays (A-P and lateral) are digitized with a 2-D digitizer to yield the 3-D coordinates of the muscle's origins and insertions with respect to an anatomical reference frame. The anatomical reference axis system is located at the geometric center of T8 vertebra with X,Y and Z defining axes the right lateral, axial and transverse directions respectively (Figure 1). The Y and Z coordinates of a point are obtained from the lateral X-ray and the X coordinate from the corresponding P-A X-ray.

Using this procedure the Cartesian coordinates of the following muscles are obtained: Trapezius, Rhomboid Major and Minor, Levator Scapulae, Splenius Capitis and Splenius Cervicis, Supraspinatus Capitis and Cervicis, Longissimus Capitis and Cervicis, Rectus Capitis Posterior Major and Minor, Superior and Inferior Capitis Obliquus, Longus Coli, Longus Capitis, Rectus Capitis Anterior, Rectus Capitis Lateral, Scalenus Anterior, Medius and Posterior, and

Sternocleidomastoid. An example of the coordinates for the Trapezius muscle is given in Table 1 and the muscle is shown in Figure 1.

References

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(A) The Axis System in Lateral View

(B) the Axis System in A-P View. The Location of The Trapezius Muscle is also Shown.

Figure 1.

Table 1

Point #	Coordinates of the Muscle (mm)					
	Origin			Insertion		
	X_o	Y_o	Z_o	X_i	Y_i	Z_i
1	-3.1	294.7	27.9	172.3	137.9	73.9
2	2.3	217.7	50.8	84.4	112.0	103.0
3	-3.6	118.5	-13.3	132.2	90.6	-0.9
4	2.6	21.8	-51.9			
5	7.2	-69.7	-27.3			